The Exploration Portable Electrostatic Detector (xPED)

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Abstract - *Astronauts and rovers, while exploring dynamic environments, can experience charge buildup through tribo-charging (contact electrification). Charge levels can become substantially high, especially in areas where photoelectric and plasma currents are reduced (e.g. lunar polar crater). Tribo-charging in areas that have little to no charge dissipative path can be severe, leaving an astronaut or roving object to remain charged for extended periods of time. Charge buildup on space suits and/or rovers is expected to present significant hazards to missions, such as electrostatic discharge and arcing, dust adhesion to space suits/equipment, and destruction of equipment. The avoidance of hazards associated with charge buildup is critical for future NASA missions to near earth objects, the Moon and Mars. The Exploration Portable Electrostatic Device (xPED) will allow astronauts to determine their charge state, and also characterize the electrical environment from their excursions. xPED would benefit manned, as well as robotic missions.*

Keywords: electrometer, tribo-charge, atmosphere.

1 Introduction

As astronauts and roving objects explore through dynamic environments, they can experience electrical charge build up through contact electrification or tribo-charging. For example, while moving along the lunar surface, an astronaut will have a dissipative path to either the ground or the ambient plasma, depending upon which path is the most conductive. At the lunar terminator region and into night-side regions, the surface is very cold and becomes a very poor conductor, leaving the plasma as the dominant remediating current for dissipation. However, within lunar craters, even plasma currents become substantially reduced which then greatly increases electric charge dissipation times [2].

Other dynamic environments, including near earth objects (NEOs) such as asteroids, and the dusty Martian atmosphere, can create scenarios where an astronaut or roving vehicle may encounter periods of accumulated electrostatic charge as well. Such accumulation of charge presents hazards to astronauts, as well as equipment, including electrostatic discharge and arcing, dust adhesion to space suits and equipment, and destruction of equipment. Therefore it is important to know the charged state of the roving object in order to prevent such hazardous effects. The Exploration Portable Electrostatic Detector, xPED, is a device that can potentially remedy this issue.

2 Instrumentation

The Exploration Portable Electrostatic Detector (xPED) is a stand-alone, miniaturized, ruggedized electrometer designed to run on batteries and be carried or worn by the astronauts and placed on or near roving systems to detect local surface charging on space suits and equipment. This device will incorporate onboard data storage for data collection and post-sortie analysis.

2.1 Origin

The design of xPED is based upon the successful electrometer build for Mars-Analog dust devil studies by Jackson and Farrell [1]. The electrometer has been successfully used to sense large electric fields from tribo-charged objects. It was used in the past for dust devil studies in California, Arizona and Nevada. Figure 1 below shows data collected from a California dust devil, with electric field versus time in seconds.

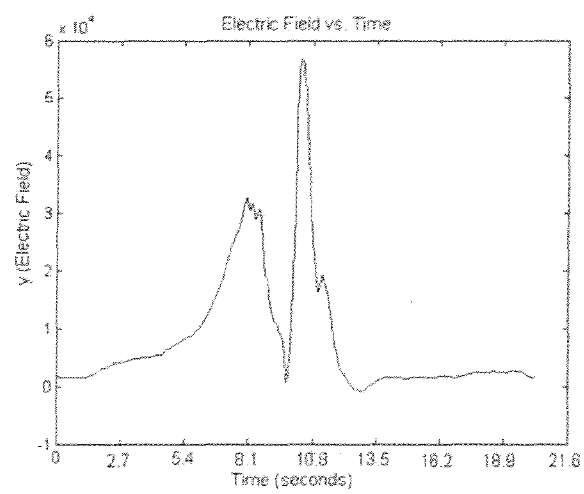

Figure 1. Electric field in a tribo-charged dust devil [1].

The electric field shown is about 58kV/m, and indicates that large tribo-electric fields are expected in mixing dust columns [1].

2.2 Current State

Presently, xPED (pictured in Figure 2) is a portable electrometer that provides an audible click as a charge alert and a voltage output that can be used to characterize the environment.

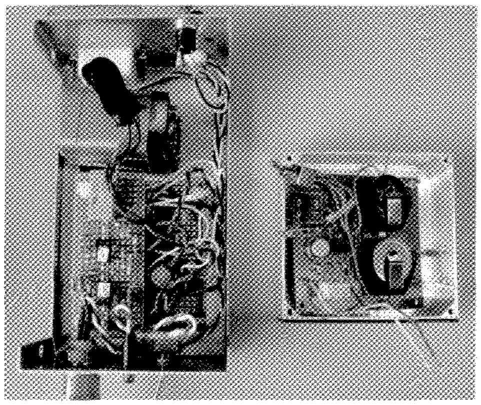

Figure 2. Early version of xPED on the left, SMT version on the right.

Both early stage versions require a data acquisition unit (DAQ) in order to capture and view the data.

2.3 Advancement

The advancement of xPED includes modification to make it applicable to more atmospheres (including extreme environments such as Mars), incorporating a digital storage capability so that it will work independently of a DAQ, and modifying the design to further miniaturize the system, as well as integrate with space suits and rovers. Figure 3 shows the early xPED system prepared for a mock Extra-Vehicular Activity (EVA) towards Desert Research and Technologie Studies (DRATS) rovers, September 2011. More on DRATS can be found at http://www.nasa.gov/exploration/analogs/desertrats/.

Figure 3. Early xPED system for mock EVA.

This was a great opportunity to test the idea of xPED, collecting, storing, downloading and analyzing roving charge data. The charge data collected during this particular test is currently being analyzed.

3 Conclusions

A small stand-alone charge hazard detector is currently unavailable for missions and xPED directly responds to this need. The end product will be a device that will be used to monitor astronaut and roving object tribo-charging, ultimately acting as a charge hazard alert, with the capability of storing roving data that can be later downloaded and used to characterize any environment that is being explored. xPED will be able to supply system-level electrostatic environmental information for any manned or robotic mission in electrically active environments.

Acknowledgment

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References

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